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NAVAL FORCE SIZING:
ZERO-BASED OR "BOTTOMS-UP" METHOD

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Decisions about the size of a military force are made in a very complex political and economic environment. This paper tries to bring the focus back to basics. In an unclassified context, using the laws of physics and current best estimate of a wartime scenario, it demonstrates the aggregate of considerations to determine the required size of naval force. It briefly applies contemporary risk theory to the difference between the required naval force and one that is fiscally constrained.

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EXECUTIVE SUMMARY

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It briefly applies contemporary risk theory to the difference between the required naval force and one that is fiscally constrained.

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I. Why a Navy - Why a Problem

A. A Navy - What Does It Do?

1. Law. As stipulated in Title 10 U.S. Code, the mission of the U.S. Navy is to be prepared to conduct prompt and sustained combat operations at sea in support of U.S. national interests. Further, by Department of Defense directive it is:

> To organize, train, and equip Navy...forces for the conduct of prompt and sustained combat operations at sea, including operations of sea-based aircraft and land-based naval air components - specifically, forces to seek out and destroy enemy naval forces and to suppress enemy sea commerce to gain and maintain general naval supremacy, to control vital sea areas and protect vital sea lines of communications, to establish and maintain local superiority (including air) in an area of naval operations, to seize and defend advanced naval bases, and to conduct such land and air operations as may be essential to the prosecution of a naval campaign.

2. Reason. Why the U.S. needs a Navy derives from the strategic environment. The United States by virtue of its geographic placement in the world is maritime dependent and hence to best support its national interests has chosen to become a maritime power. The present environment shows a U.S. dependency on foreign trade for raw materials.

To assure its autonomy and security, and to ensure the viability of the maritime economic links, the United States has chosen to participate actively in a series of alliances which call for a U.S. military characterized by peacetime forward deployments.

B. <u>A Problem</u>. Because there is no free economic market mechanism working in the Department of Defense that would insure that the "amount" of defense purchased is the "right" amount,or is "enough", a mix of subjective and objective measures are used as proxies for the market mechanism. As a result the differing perceptions of the men called upon to determine or adjudge the amount of defense will result in differing proposed force structures.

One recent example: OSD (PA&E) in the 1978 Consolidated Guidance indicated that Navy should presume that "the U.S. surface fleet could be sized for peacetime and for conflicts in which the Soviets chose not to become involved."

This created an immediate problem when it was leaked to outside interested groups, because our NATO Allies on the continent perceive that the kind of conflict that they're worried about, and for which they would need U.S. cooperation, is precisely the one that <u>does</u> include the involvement of the Soviet Union.

Norway was perhaps the most vocal in expressing its consternation and concern about these types of statements. Could it count on the U.S. or not?

In an effort to clarify the point, Secretary of Defense Brown, on 6 June 1978, delivered a major policy speech in which he said we design our Navy for the standard NATO war scenario, and highlighted the need for naval capabilities to reinforce allies on the flanks of the Soviet Union, and to control the Norwegian Sea, the Mediterranean, and the Western Pacific, as well as the North Atlantic SLOC.

Is the U.S. Navy now headed fair?

This paper focuses on one method that allows a decision maker to make an informed judgment on force needs. Labelled the "bottoms up" approach, it is a zero-based methodology, and progresses from broadly defined national security objectives to more explicit naval roles or missions to the actual forces necessary to support the missions.

II. ROLES AND MISSIONS

A. Background

In his Annual Report for Fiscal Year 1980, Secretary of Defense Brown identified three major security objectives for naval forces: maintenance of stability, containment of crises, and deterrence of a global war.[1] Related to these were the naval roles that would support them. The naval roles are shown on the left margin of Table I. Different general naval forces are related to these missions. The two primary, quantifiable, wartime missions or roles are Defense of the Sea Lanes of Communication (SLOC), and Reinforcement of Allies.

Because of previously completed campaign analyses and logistic analyses it is possible to attempt a "bottoms-up" force structure--proceeding from security objectives to naval roles or missions to the number of particular platforms needed to carry out the mission against a postulated threat.

B. SLOC Defense

The discussion begins with SLOC defense. There are three principal and interrelated tiers which comprise SLOC defense: ASW barriers across geographic chokepoints, land-based ASW aircraft SLOC patrols of the sea lanes, and convoy escort. The primary threat to a secure SLOC is the Soviet submarine. In simple terms, one finds a submarine by listening for its sound in the water, and different submarines have different noise levels. In general the best weapon platform against a

TABLE I

NAVAL ROLES AND FORCES

SECRETARY OF DEFENSE NAVAL ROLES TO SUPPORT NATIONAL SECURITY OBJECTIVES	OFFICIAL DIRECT NAVAL FORCE SIZING LINK	UNOFFICIAL BUT STRONG NAVAL FORCE SIZING LINK
Forward Deployments	CV Amphibs SSN	Surface Combatants URG
Measured Projection of Power Against the Shore	Amphibs CVTG	
Superiority at Sea in a Crisis Setting		SSN CVTG
Defense of Sea Lanes of Communication	SSN VP SOSUS Ocean Escorts	
Reinforcement of Allies	CV Ocean Escorts SSN(DS)	Amphibs
Pressure Upon Soviets		SSN CV
Hedge Against Uncertainties of Distant Future		Amphibs CV

submarine is another submarine since it is in the same environment as the opponent. In a submarine vs. submarine battle the quieter submarine has a decided advantage.

The basic analytic tool which relates to the discussion of antisubmarine warfare is the sonar equation. What follows is a derivation of that equation. It will provide the context in which one can relate and explain how to size submarines, land-based ASW aircraft, and convoy escort forces.

The offensive portion of naval warfare requires that four evolutions take place prior to the conduct of an attack. They are, in order: Localization, Detection, Tracking and Classification.

Radar and sonar systems, the primary detection equipments used by naval forces, can be described as having essentially deterministic properties because of the constraints of the laws of physics. An energy signal of certain strength is generated. In the radar case the energy transmitted is electromagnetic waves; in the sonar case it is acoustic pressure waves. It is beamed or focused toward a target. The signal's intensity decreases while traveling through the medium due to physical phenomena such as spreading, absorption, scattering, etc. A certain amount of energy from this reduced signal hits the target, if one is present. Some portion of this incident signal is reflected, some in the direction of the receiver. As this signal returns it is reduced again by travel through the medium, and some portion finally reaches the receiver. It is then processed and displayed so that an operator will be able to discern the target signal from the rest of the background clutter. In the radar case the background clutter could be weather, in the sonar case an example of background clutter could be fish.

2. The Sonar Equation. Sonar, as was mentioned earlier, is based on the discernment of acoustic pressure waves. These are measured in units called micropascals. So small are these units that the human ear is capable of hearing a minimum audible level of micropascals one ten-millionth that of the maximum.

A few representative sound pressure levels measured in micropascals will give an indication of the range of values and indicate why it was necessary to translate them to a more tractable measure, called decibels.

Sound Pressure Levels[2]

Noise	Micropascals	Decibels
Jet Plane at 100 feet	200,000,000	166
Very Heavy Traffic	200,000	106
Conversational Voice at 12 feet	6,300	76
Faintest Audible Sound	20	26

Because the decibel scale is logarithimic an increase in just 3dB relates to a 100 percent increase in sound intensity, 10 decibels (dB) measures a 10-fold increase in sound intensity; a 20 dB rise means a 100-fold increase; a 30dB rise a 1000-fold increase in pressure. To make the numbers more pliable and useful, logarithms are used rather than the pressure numbers in micropascals themselves. An example will be helpful. Suppose two acoustic signals are to be compared,

P_1 = 10,000 micropascals; P_2=.0001 micropascals. Their ratio

$\frac{P_1}{P_2}$ = 100,000,000 would be extremely cumbersome. However, when the logarithm is used

$$\log\left(\frac{P_1}{P_2}\right) = \log P_1 - \log P_2$$

$$= 4 - (-4)$$

$$= 8$$

It is customary in engineering work to multiply the logarithm by 10,

$$10 \log \frac{P_1}{P_2} = 80$$

and refer to the result as the number of decibels.

The measure for sonar capability is called Figure of Merit. It is not range dependent and yet can be related to range when propagation loss is known in terms of range. It is a direct and measurable indication of sonar capability. It is the sum of several parameters of the passive sonar equation. The sonar equation is mainly a specialized statement of the physical law of conservation of energy.

a. The Passive Sonar Equation Derivation*

(1) Consider that the target radiates a certain sound energy intensity level = L_S , measured in decibels.

(2) Enroute to the receiver the intensity of the sound is diminished due to the physical characteristics of the medium which causes the sound to reflect, scatter, spread, bend, etc. This is called propagation loss and is labeled N_W. Hence, the intensity level of the signal arriving at the receiving ship is $L_S - N_W$.

The immediate surroundings of the receiving ship characterized by own ship's noise, sea state, etc., will cause some loss in the ability of the operator to pick out the target signal. This background noise is labeled L_n and is modified by the directability of the receiving array (naturally, if one could focus the receiver in the direction of the incoming target sound it would minimize the effect of immediate surroundings). N_{DI} is called the directivity index, so that the value of a sonar signal arriving at a ship which is greater than the ship's background noise is:

$$\underbrace{L_S - N_W}_{\text{Arriving Signal Intensity}} - (\underbrace{L_N - N_{DI}}_{\text{Background Noise}})$$ and is the signal provided.

The next and final element in the passive sonar equation is recognition differential and is labeled N_{RD}. It is defined

*The active and passive sonar equation derivations that follow are distillations of more thorough derivations found in Naval Operations Analysis (Annapolis: U.S. Naval Institute Press, 1968), Ch. 9.

as the signal provided, minus the noise level required for an operator to detect a target on 50 percent of those occasions during which a target presents itself.

The passive sonar equation is

$$L_S - N_W - (L_N - N_{DI}) = N_{RD}$$

Rewritten for N_W

$$N_W = L_S - (L_N - N_{DI}) - N_{RD}$$

This expression, $L_S - (L_N - N_{DI}) - N_{RD}$, is called Figure of Merit and is the allowable transmission loss to still maintain a 50 percent probability of detection.

Figure of Merit allows for a quantitative comparison of two sonars without requiring a knowledge of the intervening medium between the ship(s) and the target. For example, Sonar A with a derived figure of merit of 72 decibels, and Sonar B with a derived figure of merit of 93 decibels would *ceteris paribus* favor Sonar B, since under the conditions defined, Sonar B can suffer 21 decibels greater propagation loss than Sonar A and still make a detection with the same 50 percent probability.

c. Modes of Sound Transmission. There are three different modes of sound transmission:

(1) direct path - the sound heard has traveled directly from the source to the receiver;

(2) bottom bounce - the sound heard has bounced off the sea bottom; and

(3) convergence zone propagation - the sound heard has been bent due to the physical phenomena of sound traveling in a nonuniform medium. Temperature, pressure, and salinity influence the sound velocity, and the depth of the water allow for sound to be refocused and heard at very long ranges.

Representative examples using the Norwegian Sea area with two figures of merit previously mentioned will demonstrate the advantage that accrues to a sonar having a 21 dB advantage on another.[3]

Area	Sonar A: 72dB	Sonar B: 93dB
	Norwegian Sea	
Direct path	3300 yds	8,000 yds
First bottom bounce	impossible	22,000 yds
First convergence zone	impossible	58,000 yds

Since in a submarine-versus-submarine battle the victory usually goes to him who detects first, one can see the awesome advantage the submarine with Sonar B has over the submarine with Sonar A.

b. The Active Sonar Equation Derivation

(1) Consider now that L_S is the radiated signal from the transmitting ship or buoy.

(2) Again the radiated signal, L_S, leaves the ship and is diminished in intensity enroute the target by an amount N_W. Hence $L_S - N_W$ arrives at the target.

(3) The target re-radiates the received signal. A new variable, target strength (N_{TS}) is introduced and is the ratio of the re-radiated intensity to the incident intensity (some energy is absorbed by the target hull's coating, etc.). Hence, the energy now returning from the target is $L_S - N_W - N_{TS}$

(4) Again this energy suffers transmission loss, N_W, enroute back.

(5) And, just as in the passive case, background noise ($L_N - N_{DI}$) must be accounted for as must recognition differential N_{RD}.

The Active Sonar equation is

$$L_S - N_W + N_{TS} - N_W - (L_N - N_{DI}) = N_{RD}$$

placing the range dependent term on the left side yields

$$2N_W = L_S - N_{TS} - (L_N - N_{DI}) - N_{RD}$$

Some typical numbers for an active sonar might be:

L_S	= sonar radiated signal level	= +140 dB
N_{TS}	= target strength	= + 15 dB
L_N	= self noise for state 2 sea	= - 43 dB
N_{DI}	= directivity index of the sonar at 2 kilocycles	= + 25 dB
N_{RD}	= recognition differential for sonar at 2 kilocycles	= + 27 dB

Marginal improvements made in increasing the sensitivity of the hydrophone, in platform quieting, or in the quality of the signal processing and display equipments can and has had significant impact on increasing the acoustic advantage one has in ASW. It is for this reason, technological superiority, that the United States has and will probably maintain a qualitative advantage on the Soviet Union in antisubmarine warfare.

3. SLOC Tier Defense. Continuing with the three SLOC efforts:

a. ASW Barrier. Because of their unfavorable geographical position Soviet submarines must transit chokepoints in going from their bases to the open ocean of the Atlantic, Pacific, or the Mediterranean Sea. These chokepoints represent the areas where the U.S. would establish the first or outer line of SLOC defense, an ASW barrier. This barrier, composed of U.S. nuclear attack submarines and antisubmarine mines, and complemented by land-based antisubmarine patrol aircraft and underwater listening posts, would, in a series of one-on-one battles, attrite the number of transiting Soviet submarines.

The ASW barrier will attrite the number of Soviet submarines, but there will be "leakers"; there will also be some Soviet submarines already on deployment when war commences. To counter this threat the next two tiers of ASW effort will be established in an effort to ensure SLOC security.

b. Land-Based ASW Aircraft SLOC Patrols. The U.S. Navy also plans to use land-based ASW aircraft to patrol the highways of the sea which will be used by the convoys.

c. Convoy Escorts. The last or inner tier of SLOC defense is comprised of surface and subsurface combatants which escort the convoys.

4. Forces. The next step in quantitative force sizing is the relating of these efforts to specific numbers of platform types.

a. SSN. Nuclear attack submarines have two major warfare responsibilities. Primarily they will be used and are sized for antisubmarine warfare, that is, against opponent submarines. Secondarily, SSNs could be used against enemy surface forces as targets of opportunity presented themselves.

This paper will not become involved in the assessment of the best ship for the job, i.e., whether a non-nuclear SS would be more effective on barrier patrol than a SSN. This paper is working from a basis of "if these are the kinds of tools we (the Navy) will have in the inventory in 198X, then how many of them do we need." If there are major technological breakthroughs, for example, in ship quieting or sonar or radar signal processing, the form of the sonar equation won't change. But since the input variables will change, the projected requirements in that environment will change.

Within an unclassified context the first step in SSN force sizing is to translate the figures of merit, own figure of merit and opponent or target figure of merit, to acoustic advantage (the difference in the two figures of merit) and from the results, using classified nomograms and graphs ascertain:

(1) an insecure sweep width (ISW)

(2) a secure detection correction factor (SDC)

(3) a secure sweep width (SSW) defined by SSW = ISW . SDC*

(4) and finally, calculate a probability of secure detection by applying a kinematic correction factor (KCF) to take into account the speed and barrier width related impacts.

Carrying through the example of Sonar A with an FOM of 72 dB on an SSN attempting to penetrate a barrier at 12 kts and Sonar B with an FOM of 93 dB on the barrier SNN patrolling at 8 kts a barrier of 60 nautical miles. Bottom bounce conditions are available.

Penetrator	Barrier
ISW_A = 4.2 NM	ISW_B = 21 NM
SDC_A = .02	SDC_B = .99
SSW_A = .084	SSW_B = 20.8

KCF = 1.2

$$\text{Probability of secure detection}_B = P_{SD_B} = \frac{(20.8)(1.2)}{60} = 0.41$$

In this example, then, our barrier SSN has a 0.41 probability of detecting a penetrating submarine with a certain FOM. One SSN then must move from a detection to a firing

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NOTE: Secure and insecure sweep swaths relate directly to secure and insecure attacks. A secure detection occurs when the subject submarine detects the target before being counterdetected. A secure attack occurs when the attacking submarine detects and closes the target to the point of torpedo fire without being counterdetected. An insecure attack occurs when both submarines are aware of each other.

solution. Let's say he has a .7 chance of doing this, and he carries a torpedo reliable 80% of the time. So the probability of killing the penetrating submarine is

.41 x .7 x .8 or about .22.

Taking this sort of data the analyst can adjust the width of the barrier or the speed of the barrier submarine to adjust the kill probability against a specifed threat to a satisfactory level. The analyst can then add up the number of barrier cells established and multiply by the cell loading factor (overhaul, transit, and overhead considerations). The resulting number is the friendly SSN fleet size for barrier patrol.

The SSN is also used in a direct support (DS) ASW mission with the carrier task group (CVTG). In this case the requirement is a derived requirement and is limited by the ability of the CVTG commander to provide effective command, control, and communication of the submarine(s) in direct support. Two or three SSNs (DS) per CVTG probably represents an upper limit with today's technology and tactics.

In the DS role the SSN acts as a semi-autonomous element of the ASW screen, usually ranging ahead of the surface ASW platform and using a variety of tactics to detect and prosecute penetrating submarines and denying them advantage of water depth characteristics that spread, deflect or absorb sound energy. These depth characteristics vitiate the effectiveness of surface platforms but have minimal effect on the DS submarine which is at depth with the penetrator.

The SSN vs. SSN scenario represents an anomoly in today's naval force calculation for three reasons (1) the engagement is generally considered to be a one-on-on duel, (2) it is like-force fighting like-force, and (3) the force requirement is derived independent of the number of Soviet SSN.

b. VP/VS. Land and sea-based fixed-wing ASW patrol force is also sized for barrier patrol, SLOC patrol, and some convoy support. Ocean search rates -- determined by sonobuoy and signal processing effectiveness; On-station time -- determined by distance from bases and human endurance factors; and availability--determined by overhaul and reliability factors, describe in an objective fashion airborne ASW requirements. Specifically, the formula for VP aircraft requirements takes the form: (taken from OSD/PA&E "Bottoms Up" Study, 1975)

$$N = \frac{H}{U\,[1 - \frac{2D}{TV}]}$$

where

N = Number of patrol aircraft

H = Number of hours in a month

U = Utilization rate in hours for each aircraft per month

D = Distance of aircraft base to barrier or far point of SLOC

T = Sortie length (flight time)

V = Transit/patrol speed

The results yield the number of aircraft needed to ensure a single VP aircraft coverage of a barrier, SLOC, convoy, or underway replenishment group.

This equation will allow a planner to calculate the "tail" required to maintain one aircraft on station. How many are needed on station can be determined by calculation using classified data involving buoy area coverage and particular mission requirements, e.g., sanitized corridors or wide ocean areas.

The primary detection equipment of ASW aircraft are sonobuoys (active and passive) which are dropped by the aircraft in a pattern with the interbuoy spacing optimized for detection of a particular threat submarine. The general nature and location of the threat would possibly be identified by the SOSUS network, a series of fixed underwater sonar arrays. These types of aircraft are most efficiently employed when vectored to a particular threat area by SOSUS information, and the aircraft, with an on-station patrol time determined by the distance from home base, would be utilized by the on-scene commander in response to the changing tactical situation.

c. <u>Escorts</u>. These forces would be used primarily as close-in antisubmarine warfare protection for convoys, replenishment groups, amphibious groups, carrier task groups

(CVTGs) and battle groups. Their strength lies in speed and sonar (active and passive) acoustic capabilities. These ships are frigates (FF), and destroyers (DD). How many are needed in a specific instance is determined by the size of the convoy or force escorted and the mix of other escorts. Generally speaking, the Central Front in Europe (CFE) war scenario requires 7-10 large convoys in the first 30 days with about 5-12 escorts (FF/FFGs) per convoy as protection. A fewer number of ASW escorts would be needed per CVTG, because it is a warship force with more indigenous protection and speed. The same is true of an underway replenishment group (URG). Probably more escorts would be needed for an amphibious task group because of the primacy of its mission and only moderate speed.

These ocean escorts would also have indigenous ASW helicopter assets (LAMPS) with sonouboys to assist the escorts in localizing, tracking, and attacking enemy submarines.

5. Summary. A rough rule of thumb calls for five convoys in the Atlantic and two convoys in the Pacific during the first 30 days of war that would call for U.S. naval units to protect. It assumes that NATO will provide escorts for an additional five convoys, yielding ten convoys to Europe during the first 30 days of war. Each convoy would be comprised of about 50 merchant ships and 5 to 10 escorts, with a total of approximately 100 ocean escorts required for SLOC defense.

C. Reinforcement of Allies

1. Introduction. The second basic mission for sizing a navy by analysis is the reinforcement of its allies. The United States, by virtue of its NATO commitment, has many allies on the flanks of the European Central Front whom it is committed to reinforce in wartime.

This mission has two threats: Soviet submarines and Soviet naval air. Recently the Soviet naval air threat has become prepotent. It has 300 first class bombers capable of ranging 1500 to 2500 nautical miles to sea and back carrying 1 to 3 air-to-surface missiles.

The U.S. Navy's prime force in ensuring allied reinforcement is the battle group or the attack carrier task group.

Again, these forces will be characterized by layers of defense: an outer air battle, area antiair warfare, electronic deception and point defense. With net closing speeds of 1000-1500 knots and over-the-horizon (150 nautical miles) missile firings, it is clear that the key to the future battle in the air is electronics. As the sonar equation is to the submarine war so the radar equation is to the air war.

2. The Radar Equation. By simplifying a series of physics equations and disregarding the second order effects of, for example, the absorption of energy by the atmosphere, a basic equation for radar can be formulated:

$$R_M^4 = \frac{P_t G A_t A_e}{P_o (4\pi)^2}$$

where

R_M = maximum range for detection

P_t = transmitted power (watts)

G = antenna gain

A_t - target area

A_e = effective antenna area

P_1 = minimum detectable power for the radar receiver

It is questionable, however, how useful this equation will be in the extremely cluttered electronic environment that would attend such a crucial battle. There would be considerable jamming (both noise and deception) by both sides. In general, noise jamming involves broadcasting radio waves so that they "overwhelm" the receiving radar. The radar can therefore not pick up its own signal, echoing off the target, from among the clutter of the other signals barraging it. Deception jamming involves "stealing" a radar signal and modifying it in some way to deceive the searching enemy radar. A common form of deception jamming is blip enhancement. It is the boosting of the echoing signal such that it appears stronger, and the target appears larger, when received back at the searching radar. The most effective single radar jamming device remains chaff: masses of metal strips which reflect radar and "blank out" enemy radar screens, making the intended target invisible amidst the clutter.

3. Antiair Tier Defense. Returning to the tiered air war defense:

a. The outer air battle. In this phase of the war each side will seek to mass numbers. Carrier-based interceptor aircraft will seek to shoot down the Soviet bombers before they get within the missile launch envelope. The Soviets will seek to evade, electronically deceive, or jam the interceptors. The interceptors in turn will try to burn through the electronic interference and launch their air-to-air missiles at the Soviet bombers. But some Soviet air-to-surface missiles are sure to be launched at the task group or battle group in which case the next phase of the battle is joined.

b. Area AAW. Each carrier is accompanied by three to five missile surface combatant ships carrying surface-to-air missiles (SAM). These missile ship bodyguards are identified by a "G", e.g., FFG, DDG, CG which indicates the ship has a surface-to-air-missile system.

The problem with today's area air defense is the slow rate of fire, for example, the maximum rate of engagement is 2-4 missiles per firing ship per minute against what will probably be in excess of 10 Soviet missiles coming in. The most impressive stride in battle group capability will be the advent of the heavy DDG with the Aegis SAM system which will allow it to shoot at a series of incoming missile threats within a minute.

c. Point defense and electronic deception. The last tier of antiair defense is the basic point defense or Vulcan/Phalanx system in conjunction with electronic countermeasure or chaff to confuse Soviet aircraft radar or pull the Soviet missiles off target.

4. Forces.

a. CVTG. Recent campaign analyses, structured for a conventional war involving the Navy's support for the NATO Northern Flank and containing the Soviet threat in the Mediterranean, identify 12 as the minimum number of U.S. naval carrier task groups worldwide with their embarked attack and fighter air wings and with the necessary AWACS, electronic warfare and tanker support aircraft. Even then the results are not too favorable to US/NATO prospects.

In addition to the main armament of the carrier task group, the aircraft, the task group needs close-in ASW and AAW protection in the form of nuclear attack submarines (SSN), destroyers (DD), and frigates (FF) for ASW protection guided missile cruisers (CGN) , guided missile destroyers (DDG),and guided missile frigates (FFG) for AAW ptoection. In a manner similar to the ASW-SLOC case the most effective mix of AAW forces can be determined based on a determined level of acceptable risk, primarily to the carrier from an incoming Soviet missile attack.

The assessment of the risk begins with a determination of the number of air-to-surface missile (ASM) platforms the Soviets could mass for an attack. The subsequent steps to risk assessment involve sequential conditional probabilities of:

(1) the interceptor stopping the firing platform prior to its launching the ASM,

(2) successful ASM launch (launch and flight reliability),

(3) the interceptor shooting down the missile,

(4) the ship missiles (second tier) shooting down the incoming ASM,

(5) successful ASM target lock-on,

(6) third tier hard kill - ship point defense shooting down the ASM,

(7) third tier soft kill - ship electronic or mechanical countermeasures causing the ASM to miss the target.

Small improvements in an outer tier will be cumulative to the inner tier by reducing the saturation or density of ASMs arriving at the inner tier(s) and thus improving their efficiency and effect. With current interceptor and surface ship ASW systems a rough rule of thumb establishes 3 to 5 anti-missile ships,including 1 to 2 Aegis per carrier and 2 to 3 ASW ships for submarine defense,for a battle group.

b. Amphibious Lift. This requirement has no specific force sizing algorithm since the Marines as a discretionary force have no hard fixed requirements to be at a particular place at a particular time. Airlift of a Marine Amphibious Force (MAF) could move them from point A to point B. What is lost, however, is the discretionary and calibrated advantage that naval lift leaves intact. An amphibious force base of approximately 60-66 ships of various kinds is considered adequate to sustain the lift of 1 MAF from CONUS to where it may be needed in a CFE conventional war. How these amphibious forces are formed and transit determines the mix and match of the escort screen.

D. Naval Support

1. Introduction. There are certain force platforms that cannot be sized directly on a primary wartime mission, but which are necessary to support the fighting forces.

2. Forces:

a. The Underway Replenishment Groups (and various support ships) are sized based on the number of battle groups and amphibious forces needed to be sustained. As a measure it would probably be logistically possible to sustain 10-12 CVTG with 7-9 underway replenishment groups of 4-5 ships each by judicious rendezvousing and replacement. Two additional replenishment groups could probably cover the enroute amphibious force logistic requirement.

II. "BOTTOMS UP" - WHAT IS IT?

"Bottoms up" force structuring begins with Navy missions or roles, derives the forces necessary to directly fulfill those roles and then derives the support or secondary forces to supplement the primary forces.

It may be illuminating to see how a "bottoms up" analyst would look at U.S. naval force trends.

Composition of US General Purpose Fleet

	1967	1972	1977	1982
Aircraft carriers	23	17	13	13
Cruisers, Destroyers and Frigates	296	225	155	190
Attack Submarines	105	94	77	94
Amphibious Ships	162	77	62	66
Patrol Ships	7	16	7	6
Mine Warfare Ships	83	31	3	4
Underway Replenishment Ships	78	59	39	42
Auxiliary Ships	169	89	62	47
Command Ships	2	0	0	0
TOTAL General Purpose Ships	925	608	418	562

Sources: For 1967, 1972 and 1977, U.S. Navy Historical Budget Data, March 1977. For 1982, information by the Chief of Naval Operations to the Senate Committee on Armed Services, Hearings on Fiscal Year 1978 Authorization, Part 2, February 3, 1977, p. 1010.

Composition of US Navy Aircraft Forces

	1967	1972	1977	Change
Operating Navy Aircraft				
Fighter and Attack	1577	1339	1219	-23%
ASW and Patrol	553	387	406	-27%
Warning	137	121	103	-25%
Helicopter	489	492	495	+ 1%
Others	1970	1563	983	-50%
TOTAL Operating Navy A/C	4726	3902	3206	-32%

Source: U.S. Navy Historical Budget Data, February 1974 and March 1977 editions.

A "bottoms up" analysis of this change would surface the following questions:

1. Have the U.S. Navy's missons changed since 1967?

2. Given the approximately same capability, platform-for-platform from 1967 to 1982, was the U.S. Navy that "over-capable" in 1967?

3. If not, has the U.S. Navy general purpose fleet efficiency increased 100 percent since 1967?

4. Is anyone minding the store?

A recently published analysis focuses on an overall problem and the probable root causes:

> The process that underlies present planning for defense has also inhibited innovative thought. There is little incentive for analysts or planners to consider situations other than the accepted contingencies, because the acquisition of any forces that are shown to be needed would not be permitted. The DoD approach shows no recognition that unexpected crises will continue to arise. It implies that Navy and Marine Corps forces can be readily and effectively employed in situations they were not planned for and against opposition they have not studied...
>
> ...Announced policies have changed dramatically over the past 18 years and so have forces, but the major force changes have been the result more of budget stringency than of policy changes. It is fiscal guidance that has really controlled the size of Navy and Marine Corps forces.[4]

The "bottoms up" approach to force sizing should allow for formal assessment of risk with both subjective and objective elements. Starting with "bottoms up" it should be possible to rephrase the question to answer, "How much is <u>not</u> enough?" It will keep inventory from driving requirements.

A. <u>Caveats</u>. Several caveats should be made about the foregoing discussion:

- There is a certain seduction in the "bottoms up" to believe that, because so many of the battle characteristics are environmentally determined and constrained by the laws of physics, one can be more precise in the development of naval force requirements than in determining requirements to fight land warfare. Judgment needs to be applied to any force determination.

- To date there does not appear to have been a true strategic analysis done - that is where one started from a scenario and worked to the derivation of forces needed. What appears to have been done is that the analysis has worked from a selected force to an inexorable outcome - a tactical analysis.

- Caution should attend hanging specific numbers of forces to this unclassified structure because U.S. forces are sized in concert with our allies, and secondarily, there is a legitimate classification problem, for example, in detailing our SSN secure sweep widths and convoy strategies. And although "explaining" naval forces won't change the fiscal fact that in the short term there just isn't enough money for it all; it (explaining) can do two things:

(1) provide a stronger quantification of the risk incurred in the future, and

(2) require the Navy to justify its judgment calls for force needs.

III. RISK

A. Introduction. Reasonable men disagree about the required base number of Navy ships. Schlesinger posited the requirement for a 575 ship Navy; Rumsfeld called for a 600-ship Navy, now Brown has called a 425-ship Navy sufficient to carry out all the roles he sees required of a navy.

Why the difference? Has the threat changed? Have the navy roles or missions changed?

Perhaps if neither the roles/missions nor the threat has changed the answer can be found in each's assessment of the risk implied by such force levels.

To return to the "bottoms up" structured force. Even if the Navy was able to be structured in exactly that manner there would be some baseline level of risk involved. This risk is caused by uncertainties in two areas.

Descriptive uncertainty* is the absence of information about the completeness of the U.S. versus Soviet naval war "system." That is, we're not sure we can completely describe all the variables involving causative events in war: e.g., Soviet strategy, tactics. The more highly complex the "system" the greater the problem of unambiguously and exhaustively describing all the possible outcomes.

Measurement uncertainty is the absence of information about a specific value of a measurable variable. That is,

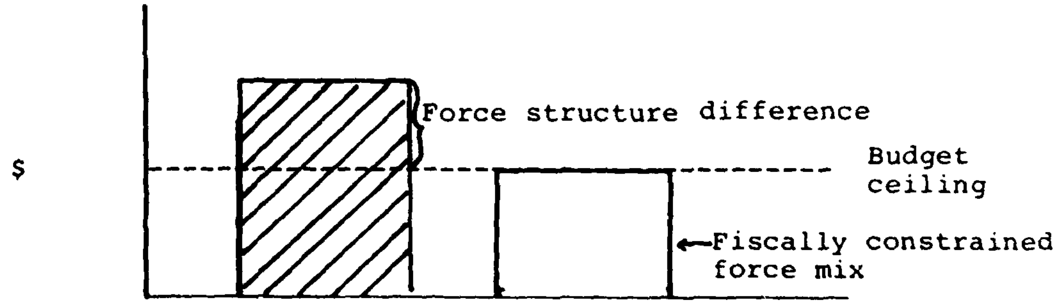
*For a fuller, more academic discussion or risk see William D. Rowe, An Anatomy of Risk (New York: Wiley, 1977) even if we could exhaustively catalogue all the variables describing a NATO war-at-sea there would still be uncertainty as to the values or range of values to give to those variables. For example, how many air-to-surface missiles does a Backfire bomber carry? What value should be given to Soviet jamming capability?

These uncertainties, and the way reasonable men handle them, have led to two schools, each characterized by the way they perceive the risk.

The "Tip of the Iceberg" school, generally focusing on descriptive uncertainty, claims that the Soviet threat is greater than the sum of hulls and weapon systems, because we don't know for sure how their weapon systems and hulls will be employed; even worse, we don't know if we've got all the variables that characterize the Soviet naval capability identified. Those of this school argue there is a real danger of catastrophe, the situation will get out of hand, and all the neat variables that analysts use in war gaming and campaign analysis, and which are carefully bound, will become unbounded or of less relevance in a post-catastrophe situation. They argue that more credence should be placed in the subjective assessment of military professionals.

The other major school that has grown up is one characterized by a "count the bodies" philosophy. They argue that, through quantitative methods to reduce measurement uncertainty, a strong case can be made that the risk is less than the sum of Soviet weapon systems and hulls, because U.S. technology will prevail. They argue for objective measures, sensitivity analyses, and campaign analyses to decide force levels and minimize intuitive military judgments. A characteristic of this school is the increasing propensity to discount the risk over time. The longer one lives on the side of a volcano the greater the tendency to disbelieve that it will ever erupt.

B. "Bottoms Up" - An Analysis of the Risk Procedure. Due to the realities of U.S. Governmental budgeting system, military "needs" are dictated by fiscal constraints in a top-down manner as budget ceilings are imposed.



Non-fiscally constrained "bottoms up" force requirement statement

The "bottoms up" force sizing applied to risk allows the force shortfall to be translated to a risk assessment. But this risk is independent of measurement and definition uncertainties. Even if measurement and definition were perfect this force shortfall implies a risk that the U.S. would not be able to carry out its mission, and implies more and more reliance on a considerate enemy.

NOTES

1. Harold Brown, Report of the Secretary of Defense Harold Brown to the Congress on the FY 1980 Budget, FY 1981 Authorization Request and FY 1980-1984 Defense Programs, January 25, 1979 (Washington: U.S. Govt. Print. Off., 1979), p. 159.

2. U.S. Department of the Navy, Director Naval Oceanography and Meteorology, ASW Oceanographic and Acoustic Support Products Manual (U) DIRNAVOCEANMETINST C3160.4 (Washington: 11 June 1976), V.I, p. B-5.

3. U.S. Naval Academy, Naval Science Department, Operations Committee, Naval Operations Analysis (Annapolis: U.S. Naval Institute, 1968), p. 156.

4. David B. Kassing, "General Purpose Forces: Navy and Marine Corps," Francis P. Hoeber, David B. Kassing, and William Schneider, Jr., eds. Arms, Men, and Military Budgets: Issues for Fiscal Year 1979 (New York: Crane, Russak, 1978), p. 77.

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